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EYE MOVEMENT AND ANTICIPATION TIME IN AN APTITUDE TEST FOR MOTOR DRIVERS

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Eye movements in the Speed Anticipation Reaction Test, which consist of two kinds of eye movements, a smooth pursuit and a saccadic eye movements, were examined using EOG. Results showed that there was marked individual difference in that saccadic eye movements, but not in the smooth pursuit movements. A high correlation was found between the frequency of eye movements and the anticipation time, which was a main measure for screening motor drivers. These results essentially supported the "motor-function-excellence" hypothesis for "hasty" responses, which has been emphasized by the authors of the test.

The Speed Anticipation Reaction Test (S.A.R.T.) is an aptitude test for motor drivers which was developed by Maruyama and Kitamura (1961). They found in this performance test that more *S*s in the accident prone group estimated the time to be shorter and reacted more rapidly than in the non- and few accident group. A measure for selection of motor drivers, therefore, is the Anticipation Time (A. T.), which is classified into three responses: hasty, semi-hasty and standard A.T. Responses peculiar to the accident prone group are called "hasty" responses, the A. T. of which is extremely brief.

The purpose of the present experiment was to investigate eye movements during the S.A.R.T., because of the following three reasons: 1) This test involves two kinds of eye movements, a smooth pursuit and a saccadic eye movement. 2) Eye movements in a visual tracking situation may reflect the strategies for an efficient information processing. Individual difference in eye movements may indicate a different efficiency of performance. 3) As the eye movements may be one of the motor components in perceptual processes, the investigation of eye movements in perceptual processes will be useful for the evaluation of the "motor-function-excellence" hypothesis for "hasty" performances, which has been emphasized by the authors of the test (Maruyama and Kitamura, 1965).

METHODS

Subjects: *S*s for this experiment were 12 male students from undergraduate and post-graduate course in medicine. Ages ranged from 19 to 33, with a mean of 22. All had a normal or corrected-to-normal vision.

Apparatus: Movements of eyeballs and eyelids were simultaneously recorded electrooculographically. The horizontal components corresponded to the movements of the eyeballs and the vertical one to the eyeblids. Results of the eyeblinks will be described in another paper (Tada, 1978). The task for *S*s a visual tracking task provided by the S.A.R.T. apparatus. Outline of the apparatus is illustrated in Fig. 1.

Procedures: Procedures identical with the original (Maruyama and Kitamura, 1961) were adopted, except for attaching five skin electrodes for EOG around the eyes. The S.A.R.T. task consists of the following four phases or stages, as can be seen in Fig. 1. Phase 1 is about a 1.3 sec period, during which *S*s can hear the sound of a motor and there are no visual changes. This sound is also a warning signal for the subsequent to the first trial. Phase 2 is continued for approximately 2.3 sec. In this phase, *S*s are required to pursue visually the spot, which appears at the right edge of the slit and move to the left at a constant apeed. Phase 3 is the period from the disappearance of spot to the key press due to the *S*'s A.T. The task of *S*s was to press the key when they estimated the disappearing spot arrived at the target point, supposing the spot to be moving behind the black panel at the same speed as in phase 2. Phase 4 is from the key press to the onset of a subsequent warning signal, the sound of the motor. Intertrial interval was about 15 sec. The horizontal visual angle of the panel was approximately 23.6 deg. for phase 2 and 21.2 deg. for phase 3.

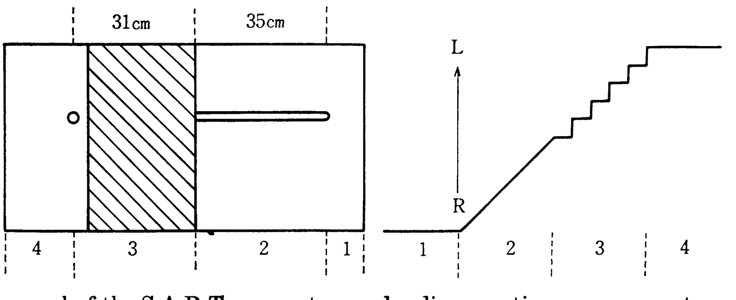

Fig. 1. The panel of the S.A.R.T. apparatus and a diagramatic eye movement record (EOG) in each phase, which exhibits a smooth pursuit eye movement in phase 2 and a saccadic eye movement in phase 3. Numbers denote the phases of the task.

Results

Mean A.T. was 2939 msec, which was fairly prolonged compared with that under usual conditions. Then other male students from the introductory course in medicine, with similar conditions as the experimental group, served as the control group under the usual conditions. The mean A.T. of the control group was 2186 msec. To compare these A.T.s the *t* test was administered after the transformation of the A.T.s to logarithmic values and the test revealed a significant difference between groups ($t=$

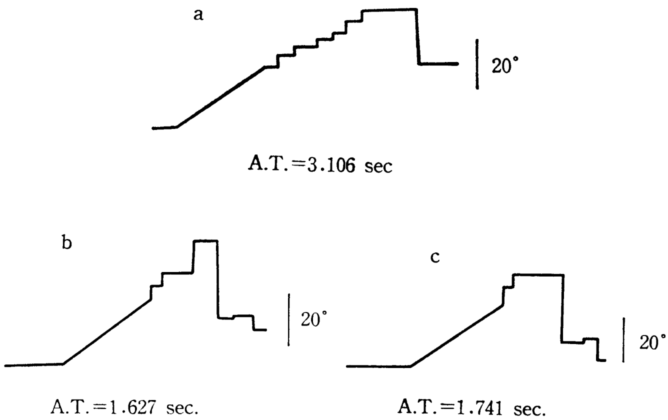

Fig. 2. Examples of eye movements of a good performance (a) and of "hasty" anticipation responses (b and c). Example a shows an uniform, periodical and frequent EOG pattern, which reflects careful and faithful saccadic movements, and b and c illustrate irregular, aperiodic and usually few saccades, which result from the eliminated and rough eye movements, in phase 3.

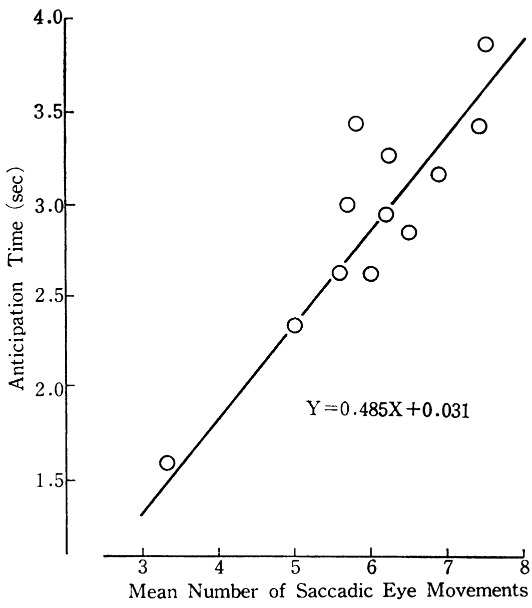

Fig. 3. Correlation between A. T. and the number of eye movements. Coefficient of correlation is .89, which may suggest that the smaller number of eye movements is apt to be the "hasty" anticipation responses.

3.071, $P<.01$).

An analysis of data for eye movements was applied to only phase 2 and 3. Fig. 2 a, b, and c display typical patterns of some *S*s in these phases. As evident in Fig. 2, the patterns in phase 2 corresponded to a smooth pursuit tracking and those in phase

3 to a saccadic eye movement, as expected.

In phase 2, few individual differences were observed in the eye movement patterns. However, frequency, pattern and periodicity of saccadic eye movements in phase 3 were markedly different from *S* to *S*. Fig. 2a exhibits an example of the record of a good performance. In this case, saccadic eye movements were uniform in pattern, periodic in cycle and more frequent in number of saccades. Fig. 2b and c showed the traces of eye movements for a case of the hasty responses. In these cases, eye movements were irregular in pattern, aperiodic in cycle, infrequent in number of saccades and therefore relatively briefer in time.

Correlation between the number of saccadic eye movements in phase 3 and A.T. is shown in Fig. 3. Countable minimum saccades in this analysis were about 1.5 deg. Saccades of less than 1.5 deg. come under the biological noises, i.e., electromyograph (EMG). Coefficient of correlation was .89 and the regression equation is as follows; $Y=0.485X+0.031$ (Y; A.T., X; the number of saccadic eye movements in phase 3). Correlation between the blink rate and the number of saccades was low both in phase 2 and 3.

Discussion

First of all, it should be noticed that the A.T. in the present experiment was markedly delayed compared with those under the standard conditions. The lag of A.T. may originate from the inhibition due to attaching the skin electrodes. *S*s were made tense during the course of recording their eye movements and blinking, and also throughout the course of task performance, by having to wear the extraneous electrodes around the eyes. The following discussion is based upon this assumption.

Results of the eye movements might contain three implications: 1) The regression equation obtained in Fig. 3, a linear relationship between the number of eye movements and A.T., suggest that a saccadic eye movement corresponds to 0.5 sec in A.T. The time of 0.5 sec may consist of the time required for movements of eyeball *per se* and for saccadic suppression or refractory period. 2) The fact that the wide-range of individual differences was observed in saccadic eye movements in phase 3 as well as in the case for blink rate, but not in the smooth pursuit in phase 2, may indicate that phase 3 should be regarded as an ambiguous situation, which yielded the individual differences in ambiguity tolerance, as the authors of the test also had presumed. 3) The high correlation of the number of saccades with A.T. may suggest that the more carefully and faithfully the eyes move, the better the performances are controlled.

Maruyama and Kitamura (1965) hypothesized the following mental mechanisms of the hasty anticipation. The speed anticipation reaction may be composed of three mental aspects; 1) to perceive the speed of the lamp objectively, 2) to decide an anticipation time exactly based on the accurate cognition of speed, and 3) to express this decision by a key pressing reaction. They pointed out at first the perceptual aspects of overestimation of speed as a contributing factor of hasty response. Recently, however, they have given attention to the motor aspects of performance, as in number 3) above. That is, *S*s of the accident prone group might fail to suppress their impulsive tendency to press the key, and perceptual accuracy might play a relatively less important role in performance.

Eye movements may be in the nature of a motor component in a perceptual system to determine the strategy for an efficient visual search. Careful eye movements usually lead to frequent saccades, whereas eliminated and rough movements correspond to infrequent saccades, and therefore probably to the accident proneness. Especially the eliminated and disinhibited eye movements might be in line with the failure of inhibition of the impulsive tendency to press the key. It could be, therefore, concluded that the "hasty" performance, at least a part of it, consists of the eliminated or rough eye movements. The evidence obtained in the present experiment also supports the "motor-function-excellence" hypothesis mentioned above.

Acknowledgement

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